Assessing changing water quality in Peru due to glacial recession

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Abstract

As concerns over future access to fresh water are beginning to spread in the United States, other more vulnerable regions like western-draining Andean watersheds in Peru are already feeling the effects of climate change on drinking water. Here, the glaciated peaks of the Andes buffer seasonal contrasts in stream runoff. However, these glaciers are now receding faster than ever before, and scientists have already recorded significant reductions in the water they supply to rivers. Furthermore, certain streams have also been found to have adversely high acidity and potentially toxic concentrations of certain heavy metals. Many such streams are used in agricultural irrigation. To test the extent and source(s) of river water contamination in Peruvian glacier-fed streams, surveys were undertaken during three consecutive dry seasons (June-July), 2011-13, to analyze the concentrations of various dissolved metals and isotopes along the Santa River draining the Cordillera Blanca to the Pacific coast. I joined the sampling survey during three weeks of June-July 2013, and I am now measuring dissolved concentrations of 32 different metals from over 60 sample locations the in Santa River watershed. Other researchers in our group are measuring the metal concentrations contained within the suspended sediments, and at the bottom of the river bed. These results will be compiled and compared against two previous surveys (2011, 2012), with a focus on certain toxic heavy metals such as lead, cadmium, and arsenic that are dangerous to human health if found above levels set by the World Health Organization. The goal of this research is to note any trends occurring in the concentrations of these metals. I hypothesize that the change in concentrations of metals will be correlated to their reactivity's and their atomic weights.

Methods

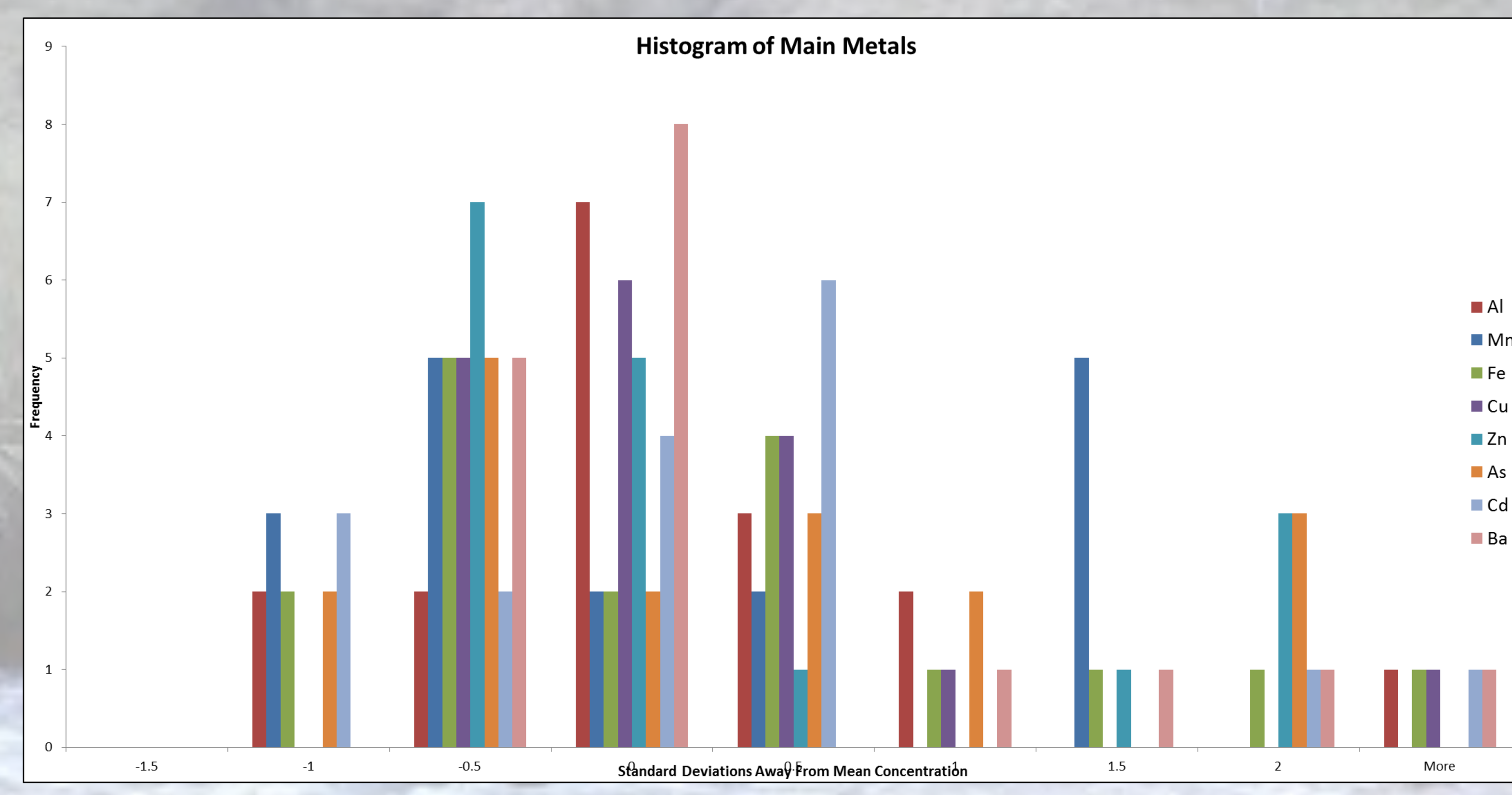
Water samples were taken in Peru during the 2013 field season using the "Clean Hands/Dirty Hands" technique. The samples were filtered into sterile 50 mL LDPE bottles. Sample contamination in the field was checked through the use of three 'test' water samples. The concentrations were determined through inductively coupled plasma mass spectrometry (ICP-MS) at McGill University. Six standards of known concentration were used to determine the concentrations while accuracy was checked every 6th sample through a standard and blank test.

Water sample being taken

Site Description

- All samples were taken directly from the Rio Santa, a river which runs through the Cordillera Blanca, and ultimately drains into the Pacific Ocean
- The Santa River is the main source of fresh water for the heavily populated Pacific coast of Peru, and is the largest continual source of fresh water draining into the Pacific Ocean in Peru
- There is concern over the impact of receding glaciers on the water quality of the Rio Santa

Results



Histogram detailing the distribution of specific metals

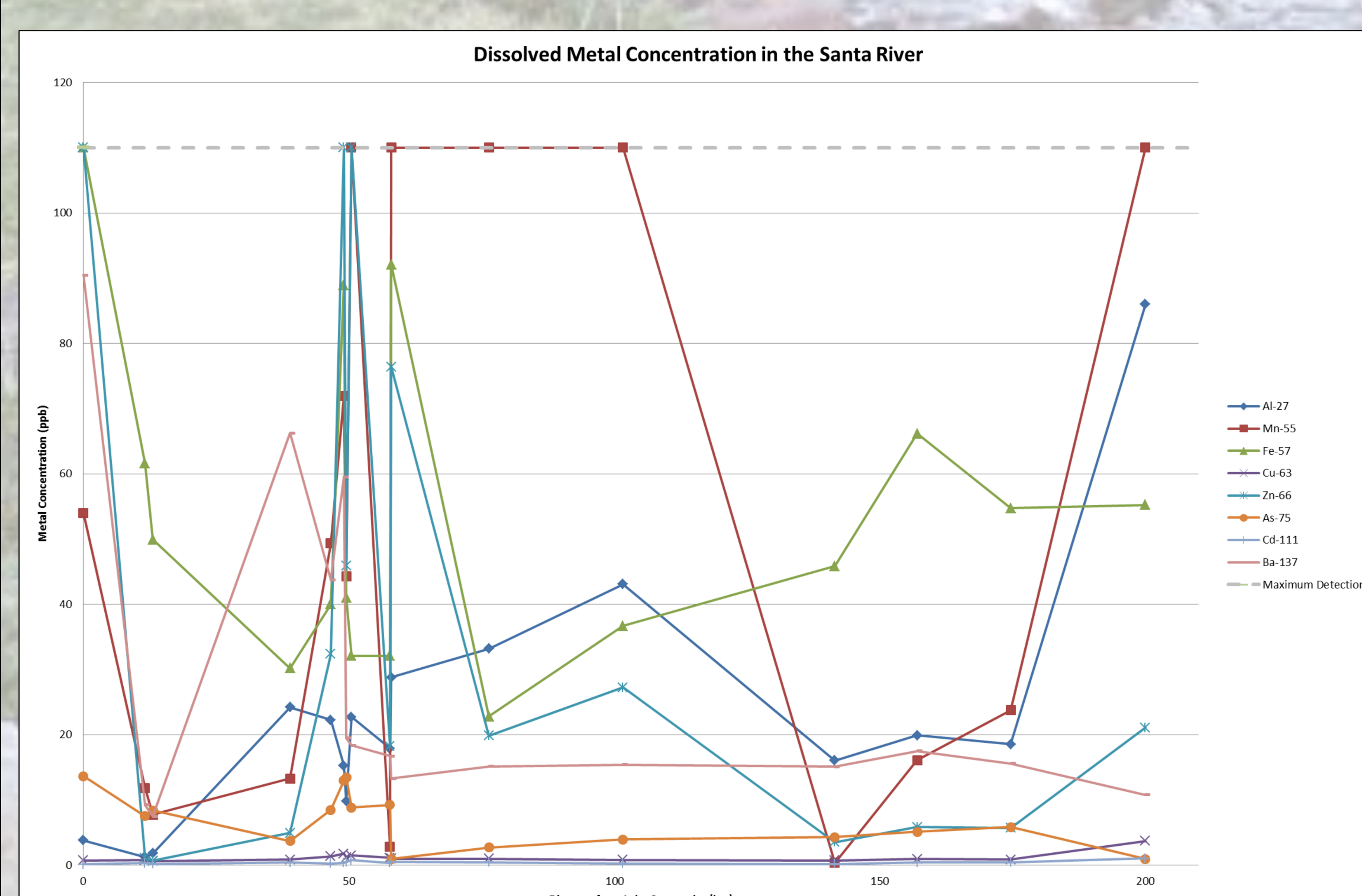
- Consists of toxic metals (As, Cd) and those most prevalent in the Rio Santa
- Average concentration of As and Cd are 6.7 ppb and 0.4 ppb (µg/L). The World Health Organization lists the maximum benign concentration of these metals as 10 ppb and 3 ppb, respectively.
- The metal concentrations tend upwards as there are no concentrations present at 1.5 or 2 standard deviations away from the mean

Pearson Correlation Coefficients

	27Al	52Cr	55Mn	57Fe	59Co	60Ni	63Cu	66Zn	75As	95Mo	107Ag	111Cd	118Sn	121Sb	133Cs	137Ba	195Pt
27Al	1.00	0.00	0.52	-0.16	**0.76**	**0.73**	**0.79**	-0.13	**-0.66**	0.40	-0.03	**0.73**	0.10	0.08	0.21	-0.26	0.12
52Cr	0.00	1.00	0.40	0.38	0.25	0.19	0.05	0.54	0.16	-0.43	**0.75**	-0.24	-0.51	-0.21	-0.17	0.27	-0.41
55Mn	0.52	0.40	1.00	0.01	**0.72**	**0.68**	0.43	0.56	-0.21	-0.21	0.30	0.51	-0.02	0.00	0.36	-0.02	-0.10
57Fe	-0.16	0.38	0.01	1.00	0.09	0.06	0.02	0.48	0.23	0.02	0.25	-0.15	-0.23	-0.32	-0.41	0.41	-0.38
59Co	**0.76**	0.25	**0.72**	0.09	1.00	**0.96**	**0.67**	0.13	-0.57	0.02	0.19	**0.66**	0.04	-0.17	0.20	-0.24	-0.02
60Ni	**0.73**	0.19	**0.68**	0.06	**0.96**	1.00	0.52	0.05	**-0.70**	0.03	0.07	0.61	0.13	-0.08	0.25	-0.28	0.07
63Cu	**0.79**	0.05	0.43	0.02	**0.67**	0.52	1.00	0.14	-0.20	0.37	0.14	**0.81**	-0.12	0.04	0.08	-0.10	-0.10
66Zn	-0.13	0.54	0.56	0.48	0.13	0.05	0.14	1.00	0.51	-0.31	0.54	0.12	-0.21	0.16	0.11	0.52	-0.39
75As	**-0.66**	0.16	-0.21	0.23	-0.57	**-0.70**	-0.20	0.51	1.00	-0.20	0.31	-0.38	-0.32	0.05	-0.23	0.49	-0.34
95Mo	0.40	-0.43	-0.21	0.02	0.02	0.03	0.37	-0.31	-0.20	1.00	-0.32	0.34	-0.08	-0.03	0.14	-0.25	-0.08
107Ag	-0.03	**0.75**	0.30	0.25	0.19	0.07	0.14	0.54	0.31	-0.32	1.00	-0.08	-0.46	-0.26	0.19	0.08	**-0.74**
111Cd	**0.73**	-0.24	0.51	-0.15	**0.66**	0.61	**0.81**	0.12	-0.38	0.34	-0.08	1.00	0.15	0.20	0.45	-0.31	0.03
118Sn	0.10	-0.51	-0.02	-0.23	0.04	0.13	-0.12	-0.21	-0.32	-0.08	-0.46	0.15	1.00	0.46	-0.03	0.13	**0.72**
121Sb	0.08	-0.21	0.00	-0.32	-0.17	-0.08	0.04	0.16	0.05	-0.03	-0.26	0.20	0.46	1.00	0.15	0.31	0.47
133Cs	0.21	-0.17	0.36	-0.41	0.20	0.25	0.08	0.11	-0.23	0.14	0.19	0.45	-0.03	0.15	1.00	-0.60	-0.35
137Ba	-0.26	0.27	-0.02	0.41	-0.24	-0.28	-0.10	0.52	0.49	-0.25	0.08	-0.31	0.13	0.31	-0.60	1.00	0.24
195Pt	0.12	-0.41	-0.10	-0.38	-0.02	0.07	-0.10	-0.39	-0.34	-0.08	**-0.74**	0.03	**0.72**	0.47	-0.35	0.24	1.00

Pearson Correlation Coefficients

- The Pearson Correlation calculates a linear relationship between two variables
- Co and Ni have the strongest linear dependence, with an *r* value of 0.927. These metals are the most closely related in terms of both atomic weight and reactivity in the data set
- A pairing with a coefficient of at least 0.65 (linear variability of at least 42%) results in a significance of 99%

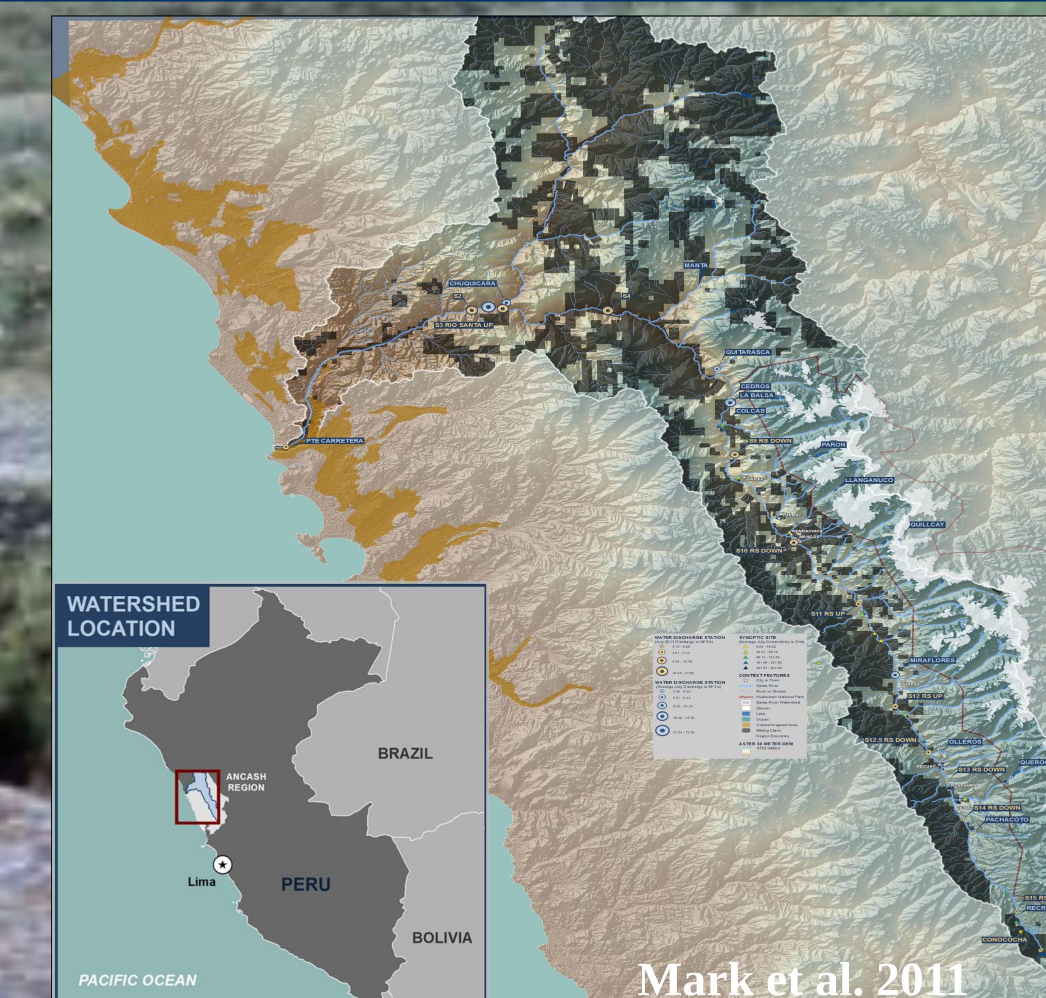


Metal Concentrations

- The areas of highest concentration are centered around Tikapampa, Olleros and Quebrada (not included in graph).
- Tikapampa and Quebrada have mine tailing along the river causing, most liely causing a strong influx of metals. Olleros is the site of the Rio Negro (Black River) which carries high loads of metals
- Arsenic exceed WHO guidelines at 3 locations; Lake Conocha (0 km), and two sites just downstream of Tikapampa

Introduction and Goals

- Utilizing the dissolved metal concentration data to plot the changes at various points on the Rio Santa
- To plot these changes of various metals based on reactivity's (right) and atomic weight.
- The plots were created based on the variance from the specific metal's mean concentration on a logarithmic scale
- Mean concentration allows the relative changes in concentration of each metal to be observed



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Discussion

- The Pearson Correlation suggests that there may be a link between a metal's weight, reactivity, and its concentration trends. However, the data remains inconclusive.
- The lack of normal distribution of metal concentration displays the broad range of factors that affect metal concentration in a given point on the Santa River, and the remaining work to be done in this project to have a better understanding of these factors.
- Some of the factors which could not be accounted for within the scope of this project include changes in concentration due to additions to the river, changing composition of the river bed, and changes in properties of the water such as temperature and pH.
- There is no evidence of a general increase or decrease in metal concentrations as one moves further downstream, further suggesting that there is a large influence on the metal concentrations by unexamined sources.

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References

Bury J, Mark BG, McKenzie J, French A, Baraer M, Huh KI, Zapata Luyo M, Gómez López RJ. 2011, *Climatic Change* v. 105, p.179-206
Carey M, French A, O'Brien E. 2012, *Journal of Historical Geography* v. 38, p.181-191
Wen LS, Santschi P, Warnken K, Davison W, Zhang H, Li HP, Jiann KT. 2011, *Estuarine, Coastal and Shelf Science* v. 92, p. 649-658
Mark BG, Bury J, Carey M, Mckenzie J, Huh KI, Barear M, Eddy A. 2011, *Thresholds of glacial hydrological change and emergent vulnerabilities in a tropical Andean waterscape.*